Estimation of light absorption by plants in situations with artificial light : Contribution of 3 dimensional virtual plants in *Helianthus annuus* and *Arabidopsis thaliana*

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Aim - Light interception is a major component of biomass production. Classical approaches to estimate intercepted light are nevertheless not adapted for experimental situations with artificial lighting. Models of 3D virtual plants and light calculation were used here to calculate the light balance for *Arabidopsis* and *Helianthus* plants grown in growth chamber and greenhouse.

1 - Variability of incident light in artificial situations

Artificial lighting and supporting structures make incident light very heterogeneous in growth chamber and greenhouse (Fig. 1). The spatial variability of incident and directional light were characterised for each experimental zone and each lighting situation (*e.g.* natural light plus artificial lights of the greenhouse). Data were integrated in the light calculation model ARCHIMED (Dauzat et al. in press)

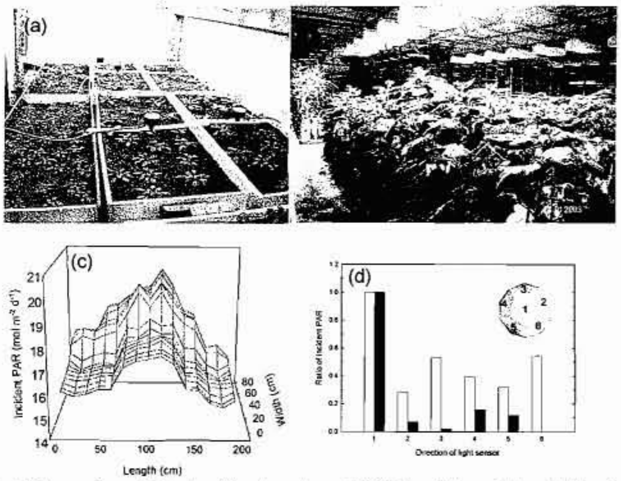

Fig. 1. Pictures of growth chamber (a) and greenhouse (b). (c) Map of the spatial variability of incident light in growth chamber. (d) Representation of the variability in the proportion of light coming from six different directions in 2 situations in greenhouse (only external light (white) or only internal artificial lighting (black)).

2 - Construction of 3D virtual plants

Virtual plants were built from measurements performed on plant over development (Fig. 2) using the plant architecture simulator AMAPsim (Barczi et al. in press) for different genotypes of *Arabidopsis* (Chenu et al. 2005 and 2007) and *Helianthus* (Rey et al. in press).

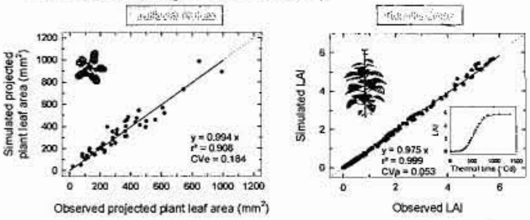

Fig. 2. Evaluation of the architectural model AMAPsim for the studied conditions (inset: dots, observed data; lines, simulated data)

3 - Estimation of light absorption

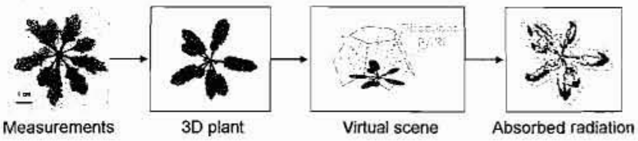

Fig. 3. Main steps to estimate the amount of light absorbed by the plant.

3D virtual plants are placed in virtual plot where the MMR model simulates the light climate and calculates the amount of light absorbed by the plant.
The fraction of intercepted light was adequately simulated with a coefficient determination of 0.990 and CVe lower than 4% (Fig. 4).

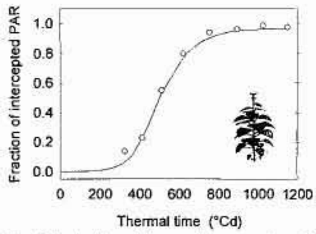

Fig. 4. Evaluation of the model: comparison of simulated (trait) and observed data (dots).

4 - Comparison with classical method of estimation of absorbed radiation

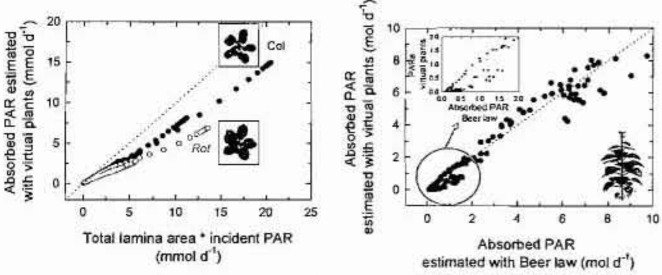

Fig. 5. Estimation of light absorption from with 3D virtual plants compared with 2 classical methods: product leaf area * incident light for 2 genotypes of *Arabidospsis*; Beer's law for *Helianthus annuus*

In *Arabidopsis*, estimation of light absorption by the product plant leaf area x incident light should be adjusted by a correction factor, genotype-specific. The developed model allows to estimate this factor for different genotypes.
In *Helianthus*, the Beer's law is an efficient way to estimate light absorption for developed crop in field, whereas 3D virtual plant coupled with microclimatic model are still adapted for other situations such as early stages of crop development, or culture in artificial light environments.

Conclusion - Coupling 3D virtual plants with a radiative model allows the estimation of light interception in any situations. This is of particular interest for artificial environments such as growth chamber and greenhouse, or for situations where classical approaches are not appropriate, *e.g.* for early developed crop in field when plants are small and the canopy highly heterogeneous.
The developed model also allows comparisons between genotypes and studies on plant architecture plasticity through the impact of various architectural traits on plant light interception.

References

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